APS
Extreme Environments, Multiple Length Scales

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Our modern world is shaped greatly by a wide range of materials with diverse properties and uses. At a fundamental level, our ability to create new useful materials depends on a detailed understanding of how atomic level processes propagate to longer length scales and how these determine material properties. Subjecting matter to extreme conditions is important because a single, closed system can be driven through multiple states with radically different properties. For example, under pressure, elemental oxygen first solidifies and then progresses through a series of insulating states, before finally metallizing at around 100 GPa; under combined pressures and temperatures, graphitic carbon can be driven from a soft conductor into diamond, which is both insulating and the hardest material known to man. When coupled with extreme environment capabilities, synchrotron beams are ideally suited to reveal the changes in structure, dynamics, and magnetic properties that accompany these transitions.

Of particular significance are the hard X-rays available at sources such as the APS, which can readily penetrate complex sample-environment set-ups. With renewal of the APS, a whole new range of experimental environments and probes will become accessible. In this talk, some of the more dramatic advances will be highlighted, with particular attention focused on future possibilities for structural characterization that bridges length scales from atomic, through nanometer, to micrometer.